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Published in:
Value in Health Regional Issues

DOI:
10.1016/j.vhri.2014.03.003

VALUE IN HEALTH REGIONAL ISSUES 3C (2014) 87–93

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/vhri

Models to Predict the Burden of Cardiovascular Disease Risk in a Rural Mountainous Region of Vietnam

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ABSTRACT

Objective: To compare and identify the most appropriate model to predict cardiovascular disease (CVD) in a rural area in Northern Vietnam, using data on hypertension from the communities. **Methods:** A cross-sectional survey was conducted including all residents in selected communities, aged 34 to 65 years, during April to August 2012 in Thai Nguyen province. Data on age, sex, smoking status, blood pressure, and blood tests (glucose, total cholesterol, low-density lipoprotein cholesterol, high-density lipoprotein cholesterol) were collected to identify the prevalence of high blood pressure and to use as input variables for the models. We compared three models, Asian, Chinese Multiple-provincial Cohort Study (CMCS), and Framingham, to estimate cardiovascular risk in the coming years in this context and compare these models and outcomes. **Results:** The prevalence of high blood pressure in these communities was lower than reported nationally (12.3%). CVD risk differed greatly depending on the model applied: approximately 21% of the subjects according to the CMCS and Asian models, but 37% using the Framingham model, had more than 10% risk for CVD. In the group without current CVD, these numbers decreased to 9% using the CMCS and Asian models but increased to 28% according to the Framingham model. There were no significant differences between the Asian and CMCS models, but differences were highly significant when comparing Asian versus Framingham or CMCS versus Framingham model. **Conclusions:** The Asian and CMCS models provided similar results in predicting CVD risk in the Vietnamese population in Thai Nguyen. The Framingham model provided vastly different results. The suggestion may be that for the specific Vietnamese setting, the Asian and CMCS models provide most valid and reliable results; however, this has to be investigated in further analyses using real-life data for potential confirmation.

Keywords: hypertension, prediction of CVD, models, risk factor.

Introduction

The burden of cardiovascular disease (CVDs) is increasing worldwide; they are a leading cause of death both globally and in Asian countries [1–3]. Of all CVDs, ischemic heart disease and cerebrovascular disease/stroke were the most common causes of death in 1990 and 2010, respectively. The mortality rate of both diseases has increased over the past two decades: approximately 35% for ischemic heart disease and 26% for stroke. In 2010, both diseases also belonged to the top five causes of years of life lost [1]. Hypertensive heart disease increased from 18.3% in 1990 to 14.2% in 2010 in the global ranking of causes of death. In Vietnam, CVD was among the top 10 leading causes of death in 2006, 2007, and 2009 [4,5]. Around 32% of deaths from noncommunicable diseases in rural areas are caused by CVDs [6,7].

To make the best use of limited resources, planning of health care interventions is important. Predictive modeling of the risk of CVD can render valuable information for planning these health interventions.

The first step in the prediction of the CVD risk is the selection of the best-fitting model for the Vietnamese population. Over the last decade, several models have been developed and validated. The first well-known model was developed in the United States using data from the Framingham study. This model, however, might be less reliable in other populations and has overestimated or underestimated the CVD risks in specific settings [8,9]. Therefore, other models were developed, such as the Systematic Coronary Risk Evaluation model in Europe [10], a risk model based on QRESEARCH database in the United Kingdom [11], the Prospective Cardiovascular Münster study in Germany [12], a risk model assessing cardiovascular risk, using SIGN guidelines to *assign* potential patients to preventive treatment in Scotland [13], and a risk model based on database of CUORE Cohorts Project in Italy [14]. In Asia, models to predict CVD risk have been developed in Thailand, China (Chinese Multiple-provincial Cohort

Conflict of interest: The authors have indicated that they have no conflicts of interest with regard to the content of this article.

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http://dx.doi.org/10.1016/j.vhri.2014.03.003

Study [CMCS]), Japan, Malaysia, and Singapore. For all Asian populations, a tool was developed on the basis of six cohorts in this region (Asian model) [8,15–21]. Because all these models vary in different aspects such as the time horizon used, characteristics of study population included, input variables, and outcome, they may all produce different results. In Vietnam, with its own environment of biological, behavioral, and social characteristics, there is not yet a specific model to predict CVD. The largest survey on risk factors for CVD done in Vietnam applied the Framingham model only [22]. Also, the Framingham model is explicitly introduced on the Vietnam Heart Association Web site. The aim of this study was to calculate the CVD risk using two prediction models developed in Asia and to assess to what extent these results coincide with CVD risks calculated using the long-established Framingham model. In this way, we hope to identify the most suitable model to predict future patterns of disease for health planners in Vietnam.

The second step for modeling the CVD risk is information on risk factors and demographic characteristics of the population. It is well known that improved CVD management could be approached through changing lifestyle. In addition, there are concerns on the capacity of health services to adequately detect risk factors such as hypertension. It is estimated that half of the expected 25% hypertensive individuals in the population are not aware of their hypertension [23]. Better CVD management is a public health concern, and hypertension detection and treatment are crucial elements in that management. There have been large surveys on hypertension in Vietnam [22,23]. This report describes a smaller but potentially more intensive study. A specific subaim of our study was to collect complete and reliable data to assess the prevalence of hypertension and distribution of risk factors in four rural communities in a mountainous area in the North of Vietnam, subsequently to be used as input variables for CVD models.

Methods

Models

As described above, several CVD prediction models are available around the world. In this study, we selected two models developed in Asia because their target populations may share a similar background of disease and risk factors for CVD to Vietnam. This would avert the potential overestimation or underestimation that may appear when the Framingham model or others developed for Western countries are used. The Asian model was validated on the basis of six cohorts in Asia and may be most representative for Asian countries. The CMCS model was developed on the basis of cohorts in 11 provinces in China. We are interested in this model as well because Vietnamese share a background of mortality patterns with the Chinese: The share of CVD was 40% in Vietnam and 38% in China among deaths due to noncommunicable disease, which account for 80% of all deaths in China and 75% of all deaths in Vietnam. Age-standardized death rate per 100,000 due to CVD and diabetes was similar in China and Vietnam (males: 311.5 and 381.5 in China and Vietnam; females: 259.6 and 298.2 in China and Vietnam, respectively). The incidence of high blood pressure (BP) in 2010 was 38.2% in China and 33% in Vietnam. Patterns of obesity or overweight may, however, be different [24,25].

We also applied the Framingham model, which is widely used and also—as mentioned earlier—is presented on the Vietnam Heart Association Web site. This tool was developed from a cohort of Americans who were free of coronary heart disease and diabetes to predict the 10-year risk of myocardial infarction and coronary heart death.

Risk factors included in the models differ to some extent. Information on sex, age, and smoking status is, however, included in all the three models. Furthermore, the CMCS model includes information on diabetes, stage of hypertension, total cholesterol, and high-density lipoprotein cholesterol. In the Asian model, systolic blood pressure (SBP) and total cholesterol are used as input variables. In the Framingham model, the following variables are used: total cholesterol, high-density lipoprotein cholesterol, and SBP.

We calculated the CVD risk of each individual using the equations of CMCS and Asian models, which consider the above input variables, and their own mean survival rate, regression coefficients, and mean values of the risk factors in the CMCS or Asian model. In the Framingham model, we calculated the point score of each input variable and translated point scores into risk levels, guided by the Framingham Heart Study. The CMCS, Asian, and Framingham models have been described in detail [8,26,27].

The CVD risk was assessed using all the three models for two scenarios. The base case excluded all cases with current CVD, whereas in the sensitivity analysis, all cases, both with and without current CVD, were included.

Study Population and Study Design

A cross-sectional study was conducted from April to August 2012 in Thai Nguyen, a mountainous province in the north of Vietnam. Four districts, all around 40 km from Thai Nguyen city, were purposively selected; we then chose one commune in the middle of each district. Within each commune, all villages having an active health care worker were listed. From this list, we selected randomly enough villages to cover 45% to 50% of the total population in that commune.

All residents from 35 to 64 years old in each village were invited to participate in the study. Exclusion criteria, based on self-reported medical history or alcohol consumption, were current pregnancy, mental health disease, heavy alcohol consumption (often drunk), cancer, AIDS, current treatment of hypertension or diabetes, or a medical history of myocardial infarction, stroke, heart failure, or kidney failure.

Medical students and village health workers, who were trained on BP measurement and on using the study questionnaires, collected data at a village center or in the household. Data were collected on demographic characteristics (sex, age, ethnicity, education, occupation, and residence) and risk factors for CVD (smoking, alcohol consumption), and BP was measured. All subjects who had SBP of 140 mm Hg or more and/or diastolic blood pressure (DBP) of 90 mm Hg or more were invited to visit the community health center for a second BP measurement 5 to 7 days after the first measurement. All subjects who still had SBP of 140 mm Hg or more and/or DBP of 90 mm Hg or more on the second day were medically examined, an electrocardiogram was done (ECG), and blood samples were collected. These people were advised to manage high BP at their community health center or were referred to a higher level for further investigation. All subjects who had SBP of less than 140 mm Hg and/or DBP of less than 90 mm Hg were advised to check their BP regularly.

Measurement and Classification

BP measurement: Participants were advised to avoid drinking alcohol the day before the visit, and to stop smoking cigarette, drinking coffee/tea, and taking exercise for at least 30 minutes before their BP measurement. Automatic sphygmomanometers (OMRON, model HEM-7200-C1, Omron Healthcare, Kyoto, Japan) with an appropriate sized cuff were used. BP was measured twice for everyone, with participants in a sitting position after at least 10 minutes of rest. A third measurement was performed if the difference between the first two was more than 10 mm Hg for SBP or DBP. Average SBP and/or DBP of the first and second or second and third measurements was used for analysis [28,29]. Hypertension was defined as an SBP value of 140 mm Hg or more and/or a DBP value of 90 mm Hg or more on the second visit. It has been recommended that in a setting of scarce resources, the value of BP at the second visit would be suitable for a reliable measurement of the real prevalence of hypertension in the community [30]. Hypertension was classified according to the Seventh Joint National Committee on Hypertension Classification [31].

Occupations were assigned to one of seven categories: farmer, worker, businessperson, wage earner, housewife, government officer, and other.

At the second visit, patients were examined by medical doctors from Thai Nguyen University of Medicine and Pharmacy. For this study, we defined coronary heart disease (including angina, left ventricular hypertrophy, myocardial infarction, or heart failure) by medical history, physical examination, and result of ECG. Blood tests (glucose, total cholesterol, low-density lipoprotein cholesterol, high-density lipoprotein cholesterol) were performed by a team from Thai Nguyen General Hospital. Diabetes was defined as fasting blood glucose level of 7 mmol/L or more [32]. Subjects who smoked cigarettes or pipe during the last month were defined as current smokers.

Statistical Analysis

Chi-square, student's *t* test, or Mann-Whitney test were used to compare differences in biological factors among different visits, different groups, and the distribution of CVD in different models. Chi-square testing was used to compare model differences. On the basis of the Guideline for Assessment and Management of Cardiovascular Risk, we used 10% as the cutoff point for CVD risks over a 10-year period. In particular, it is stated that with a 10-year risk of CVD of more than 10%, subjects need to be monitored regularly [33]. All statistical analysis was performed using STATA 10.

Ethical Issues

The research proposal was approved by the Institutional Review Board in biomedical research in the Institute of Social and Medical Studies in Vietnam. The study was explained to all those invited to join, and all subjects signed a consent form before participating in the study. All participants had the right to withdraw from the study at any time. Patients who were found to have high BP were advised to manage it at their community health station or were referred to a higher level for specialist examination if needed. Subjects without high BP were advised to monitor their BP regularly.

Results

Study Population Characteristics

The 3779 subjects who participated in the study comprised 86.5% of all those who were invited (Fig. 1). They included 43.3% men, and 84% were ethnically Kinh (the majority ethnic group in Vietnam). The most common occupation (72.5%) was farmer, and the mean age was 47.4 ± 8 years.

In this study, hypertension prevalence is a key factor and an important input variable. We therefore first present the data on hypertension prevalence, followed by the CVD model results.

Prevalence of Hypertension

The distribution of BP among 3779 subjects at the first visit is presented in Table 1. Among this study population, 776 subjects (20.5%) had an SBP value of 140 mm Hg or more and/or a DBP value of 90 mm Hg or more during the first visit. The prevalence of elevated BP was greater among men than among women (28.3% vs. 14.6%, $P < 0.001$) and increased with age (10.5%, 23.9%, and 33.4% in 35–44-, 45–

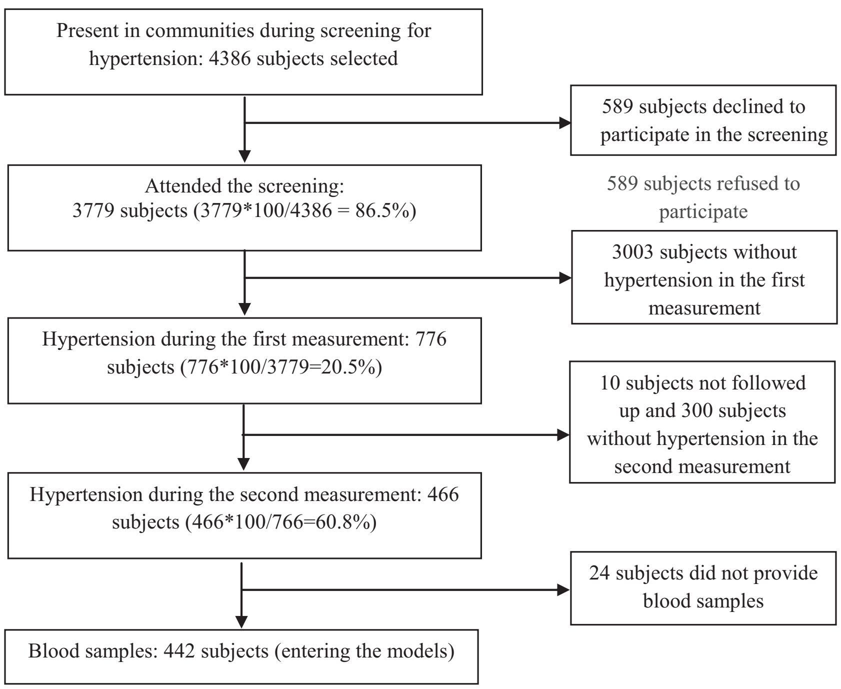

Fig. 1 – Flowchart of selecting the final sample. ***Notes.*** **We selected all subjects with hypertension in the second measurement. We required blood samples from all cases to have values for all variables to be included in the analysis with three models.**

Table 1 – Prevalence of blood pressure classification in study population, stratified by sex and age group (%) at first visit (n = 3779).

Study population	Normal	Prehypertension	Stage 1	Stage 2	P
Men (y)					
35–44	30.6	52.9	13.2	3.3	0.000
45–54	22.0	45.2	21.8	11.0	
55–64	19.1	38.0	26.0	16.9	
Women (y)					
35–44	64.5	29.6	4.3	1.5	0.000
45–54	46.7	36.0	12.6	4.7	
55–64	36.5	37.3	18.1	8.1	
Total					
Men	24.9	46.8	19.2	9.1	0.000
Women	51.7	33.7	10.5	4.2	
Both sexes	40.1	39.4	14.2	6.3	

Notes. The blood pressure level was classified according to JNC 7: Normal: SBP/DBP $<$ 120/80 mm Hg; prehypertension: SBP/DBP is 120–139/80–89 mm Hg; stage 1: SBP/DBP is 140–159/90–99 mm Hg; stage 2: SBP/DBP $\geq$160/100 mm Hg; men vs. women: P = 0.000. DBP, diastolic blood pressure; SBP, systolic blood pressure.

54-, and 55–64-year-old age groups, respectively, $P < 0.001$). During the second visit, at which 766 subjects appeared, 466 subjects (60.8%) still had a high BP. Using the BP values of this second visit, the overall prevalence of hypertension in the total population (3779 subjects) was 12.3%, including 16% of men and 9.6% of women ($P < 0.001$).

Both the median and mean value of the SBP and DBP were lower at the second visit compared with measurements during the first visit (mean 151.3 and 147.7 mm Hg; median 148 and 145 mm Hg at the first and second visits, respectively, $P < 0.001$). The range of BP at the second visit, however, was greater than at the first visit. Biological factors among hypertensive subjects (at second measurement) are presented in Table 2. Because blood tests data of 24 subjects were missing, data on only 442 subjects are presented. Age, fasting glucose, and SBP were comparable between men and women ($P > 0.05$). Total cholesterol and low-density lipoprotein cholesterol levels were lower in men ($P < 0.05$ and $P < 0.01$, respectively), whereas high-density lipoprotein cholesterol level was higher in men ($P < 0.05$).

Comparison of Future Patterns of CVD Using CMCS, Asian, and Framingham Models

Risks of coronary heart disease were estimated using three models: the CMCS, Asian, and Framingham models. In the base case, we excluded cases with a diagnosis of CVD at the time of

Table 2 – Characteristics of hypertensive patients (n = 442 subjects).

Characteristics	Model used	Men (n = 244)	Women (n = 198)	Both sexes	P
Age (y), mean ± SD	CMCS, Asian, Framingham	52.1 ± 7.8	53 ± 7.3	52 ± 7.6	0.249
Smoking (%)	CMCS, Asian, Framingham	38.93	0	21.49	0.000
Diabetes (cases)	CMCS	3	2	5	0.828
SBP (mm Hg), mean ± SD	Asian	159 ± 15.7	158 ± 14.7	158 ±15	0.505
Stage of hypertension (cases)	CMCS, Framingham				
SBP 140–159 mm Hg or DBP 90–99 mm Hg		132	116	248	0.344
SBP ≥ 160 mm Hg or DBP ≥ 100 mm Hg		112	82	194	
TC (mmol/L), mean ± SD	Asian	5.03 ± 1.51	5.22 ± 1.17	5.11 ± 1.37	0.015
TC (cases) CMCS, Framingham (mg/dl)					
<160		59	36	95	0.127
160–199		93	64	157	0.206
200–239		58	60	118	0.123
240–279		23	28	51	0.123
≥280		11	10	21	0.790
HDL-C (cases) CMCS, Framingham (mg/dl)					
<35		21	22	43	0.377
35–44		63	58	121	0.415
45–49		45	35	80	0.835
50–59		57	53	110	0.410
≥60		58	30	88	0.024

CMCS, Chinese Multiple-provincial Cohort Study; DBP, diastolic blood pressure; HDL-C, high-density lipoprotein cholesterol; SBP, systolic blood pressure; TC, total cholesterol.

Table 3 – Prevalence of risk of cardiovascular events according to different models in rural mountainous Vietnam, stratified by sex and age group (excluding cases having CVD) (%).

Study population	CMCS			Asian			Framingham		
	<10%	≥10%	P	<10%	≥10%	P	<10%	≥10%	P
Age group (y)			0.000			0.000			0.000
35–44	100			100			96.67	3.33	
45–54	98.77	1.23		93.87	6.13		80.37	19.63	
55–64	73.62	26.38		84.66	15.34		53.99	46.01	
Sexes			0.000			0.000			0.000
Men (n = 203)	100			84.24	15.76		46.8	53.2	
Women (n =183)	75.41	24.59		98.36	1.64		99.45	0.55	
Both sexes (n = 386)	88.34	11.66		90.93	9.07		71.76	28.24	
P					0.000				

Notes. CMCS model vs. Asian model: P = 0.238; CMCS model vs. Framingham model: P = 0.000; Asian model vs. Framingham model: P = 0.000.
CMCS, Chinese Multiple-provincial Cohort Study; CVD, cardiovascular disease.

examination at the second visit in all models (Table 3). The prevalence of "more than 10% CVD risk" when the Framingham model was applied was 28.24%, higher than that for the CMCS (11.7%) and Asian (9.1%) models. For women, 24.6% were at more than 10% CVD risk according to the CMCS model compared with only 1.6% and 0.5% in the Asian and Framingham models, respectively. In the age group 55 to 64 years, the prevalence of more than 10% CVD risk was highest (46%) using the Framingham model and lowest (15.3%) with the Asian model. The differences in the results between the CMCS model versus the Framingham model and the Asian model versus the Framingham model were highly significant ($P < 0.001$). There were, however, no significant differences between results from the CMCS and the Asian ($P > 0.05$) models.

In the sensitivity analysis, we included cases with a diagnosis of CVD at the examination at the second visit in each of the three models, and placed those cases in groups with more than 10% CVD risk (Table 4). The prevalence of more than 10% CVD risk was highest in the Framingham model (22.2%, 20.6%, and 37.3% in CMCS, Asian, and Framingham models, respectively; $P < 0.01$). The prevalence more than 10% CVD risk in women was similar in the Asian and Framingham models (8% and 9% in Framingham and Asian models, respectively), but it was three times higher when the CMCS model was used (30.3%). In contrast, the prevalence of more than 10% CVD risk in men was lowest using the CMCS model (16.8%) and highest using the Framingham model (61.07%). CVD risk increased with age in all models ($P < 0.001$). In the 55- to 64-year-old group, the prevalence of more than 10% CVD risk was 25.4%, 35.1%, and 52.4% in the Asian, CMCS, and Framingham models, respectively.

Discussion

Hypertension is a key risk factor for CVD, which is a leading cause of death in Asia and in Vietnam. Prediction of CVD risk by using the most appropriate model for Vietnamese population would support the management of CVD in curative and preventive health care. In this study, we predicted CVD risk among hypertensive patients by using and comparing three established prediction models.

BP measurements were taken during the first visit to the community and for those with high BP, again on the second visit a few days later [30]. The prevalence of high BP decreased from 20.5% at the first visit to 12.3% at the second visit, which is low compared with results from previously reported studies in Vietnam (25.1% and 26.4%) [22,23]. The difference could be explained by differences in study methods and geographical

Table 4 – Prevalence of risk of cardiovascular events according to different models in rural mountainous Vietnam, stratified by sex and age group (including cases having CVD) (%).

Study population	CMCS model			Asian model			Framingham model		
	<10%	≥10%	P	<10%	≥10%	P	<10%	≥10%	P
Age group (y)			0.000			0.046			0.000
35–44	88.24	11.76		88.24	11.76		85.29	14.71	
45–54	85.19	14.81		80.95	19.05		69.31	30.69	
55–64	64.86	35.14		74.59	25.41		47.57	52.43	
Sexes			0.001			0.000			0.000
Men (n = 244)	83.2	16.8		70.08	29.92		38.93	61.07	
Women (n = 198)	69.7	30.3		90.91	9.09		91.92	8.08	
Both sexes (n = 442)	77.85	22.15		79.41	20.59		62.67	37.33	
P					0.000				

Notes. CMCS model vs. Asian model: P = 0.415; CMCS model vs. Framingham model: P = 0.000; Asian model vs. Framingham model: P = 0.000; men vs. women: P = 0.000.
CMCS, Chinese Multiple-provincial Cohort Study; CVD, cardiovascular disease.

setting. A previous study used sampling in a 25 years or older population in both urban and rural areas; blood tests were conducted in 20% of the urban study population, and BP was measured during one visit. Our study was conducted in a rural mountainous area, measuring all the village population from 34 to 65 years old, and the BP was measured on two separate occasions in all subjects with high BP at the first visit. The prevalence of high BP in our study was within the range reported in other low- and middle-income countries in Asia (15%, 29%, and 44.6% in Cambodia, Malaysia, and Mongolia, respectively) [34]. Again, these studies measured the BP only at a single visit, which may lead to overestimates of high BP prevalence. This finding suggests that researchers must be careful in identifying the burden of disease in a specific setting and group; accurate data are needed for planning and allocation of scarce resources.

CVD risk differed largely depending on the model applied: approximately 9% of the subjects according to the CMCS and Asian models, but using the Framingham model, 28% had a more than 10% risk for CVD. The percentage of subjects having a more than 10% CVD risk in our study (9%–28%) was lower than that reported in previous studies in Vietnam (40.9%), possibly because they used the Framingham model only. It was high compared with the numbers reported from other Asian countries in the age group 40 to 64 years (3%, 5.6%, 3.9%, and 11.4% in Cambodia, Malaysia, China, and Mongolia, respectively) [22,34,35]. This comparison, however, is of only limited validity because different methods were used to estimate CVD risk in these studies. Studies in other Asia countries used WHO/ISH risk prediction charts and were aware of the potential underestimation of CVD risk [34]. The earlier study in Vietnam may have overestimated the CVD risk also because it measured BP only at one visit and did blood tests only on the urban sample. These limitations may present a challenge for both curative and preventive care in CVD management based on such data.

In our study, inclusion or exclusion of current CVD was found to affect the predicted future pattern of CVD risk differently in each model. The results from the CMCS and Asian models were comparable, but results from the Framingham model differed significantly. None of these models have yet been validated in Vietnam. Previous studies have suggested that applying the Framingham model in Europe and Asia resulted in overestimates of the burden of disease, where there were lower rates of CVD [8,13,36–39]. The differences when using the three models can be explained by the different components in each model, such as characteristics of study population, input variables, outcome variables, time horizon, and values in each equation. The Asian model considers the mean age, SBP, total cholesterol, and smoker/nonsmoker; outcome is defined as cardiovascular death, nonfatal myocardial infarction, and nonfatal cerebrovascular events in the following 8 years. The CMCS equation uses a subgroup of risk factors, no mean values as in the Asian equation, and outcome is defined as coronary death and myocardial infarction in the coming 10 years.

Vietnam should of course ideally have its own cohort to feed these models to predict CVD risk and validate models for the national setting. Even building an own Vietnamese model could be considered, may be an adaptation of one of these existing models. Because of the long time needed for that, and because of resource constraints, however, it may initially be very legitimate to use a model from countries with similar contextual factors, such as the CMCS model or the Asian model, to predict patterns of CVD risk in the coming years as a basis for planning and management of services in Vietnam.

There are limitations to our study. First, we could not confirm high BP using ambulatory BP monitoring. Measurements taken at two visits, however, are considered acceptable for low-resource settings [30]. Second, we identified cases with current CVD on the basis of only medical history, clinical examination, and ECG, so we may have lost cases with CVD without clinical symptoms and signs in ECG. Third, the CMCS, Asian, and Framingham original models can be applied to general populations. In this study, we tested them only in hypertensive patients, which reflect a limitation of our study. Notably, this may reduce the generalizability of our findings. Finally, availability of real data at the current stage does not allow us to demonstrate the appropriateness of one prediction model over the other; that is, we cannot infer which model(s) is (are) best for the specific Vietnamese population. The suggestion certainly is that the CMCS and Asian models could provide most reliable and valid results, but further research in practice has to substantiate this hypothesis.

In conclusion, the prevalence of high BP in a rural mountainous area of Vietnam was found to be lower than previously reported for Vietnam, but still sufficient to warrant attention from health services. Our results demonstrate that the Asian and CMCS models provided similar outcomes in predicting CVD risk in the Vietnamese population. Prediction of risk using the Asian and CMCS models than the Framingham model could be suggested to be more appropriate for the Vietnamese context because they are from the same region. The Framingham model also provides vastly different results. The suggestion that for the specific Vietnamese setting, the Asian and CMCS models provide most valid and reliable results should however be investigated in further analyses using real-life data for potential confirmation. The results of this study are useful to health planners and will provide a basis for a further study on cost-effectiveness modeling of CVD management.

Acknowledgments

We thank Dr. Nguyen Tien Dung, Dr. Duong Danh Liem, and Dr. Vu Tien Thang for their support for patient examinations at community health center and Dr. Hac Van Vinh for his communication with health services. Thanks also to Trung Thanh, Cu Van, Tuc Tranh, and La Hien for cooperation in data collection. We thank Prof. Anushka Patel and Dr. Federica Barzi for providing specific information on the Asian model.

Source of financial support: This study was funded by a project called "Centers of Excellence for Human Resources for Health: University-based Centers to Act as Resource and Transfer Point for Development Across the Health Sector in Viet Nam," financed by the Royal Netherlands Embassy in Hanoi.

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